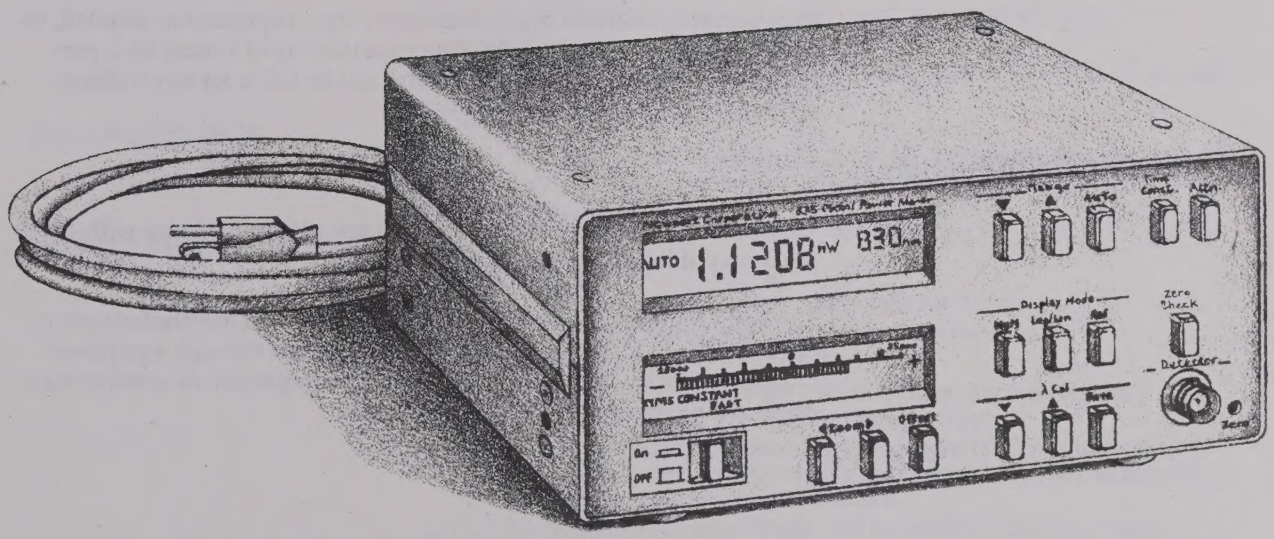
Laser Pico-Watt Digital Power Meter Model 835 Operating Manual



MP MASTER
MA29626

Newport

WARRANTY

Newport Corporation warrants this product to be free from defects in material and workmanship for a period of 1 year from date of shipment. If found to be defective during the warranty period, the product will either be repaired or replaced at Newport's option.

To exercise this warranty, write or call your local Newport representative, or contact Newport headquarters in Fountain Valley, California. You will be given prompt assistance and return instructions. Send the instrument, transportation prepaid, to the indicated service facility. Repairs will be made and the instrument returned, transportation prepaid. Repaired products are warranted for the balance of the original warranty period, or at least 90 days.

Limitation of Warranty

This warranty does not apply to defects resulting from modification or misuse of any product or part. This warranty also does not apply to fuses, batteries, or damage from battery leakage.

This warranty is in lieu of all other warranties, expressed or implied, including any implied warranty of merchantability or fitness for a particular use. Newport Corporation shall not be liable for any indirect, special, or consequential damages.

Statement of Calibration

This instrument has been inspected and tested in accordance with specifications published by Newport Corporation.

The accuracy and calibration of this instrument and the photodetector are traceable to the National Bureau of Standards through equipment which is calibrated at planned intervals by comparison to certified standards maintained at Newport Corporation.

© 1987 Newport Corporation
18235 Mt. Baldy Circle
Fountain Valley, CA 92708
(714) 963-9811

P/N 13767-01
IN-01872

Model 835 SPECIFICATIONS

Range[2]	Resolution[2]	Electrical Accuracy 18°C-28°C (1 Year) ±(%rdg + %full scale)[1]	Analog Rise Time (10%-90%)
2 nW	0.1 pW	0.4 + 0.2	60 msec
20 nW	1 pW	0.4 + 0.05	60 msec
200 nW	10 pW	0.2 + 0.05	6 msec
2 µW	100 pW	0.15 + 0.05	3 msec
20 µW	1 nW	0.1 + 0.05	3 msec
200 µW	10 nW	0.1 + 0.05	1 msec
2 mW	100 nW	0.1 + 0.05	1 msec

Notes:

1. When properly zeroed. Detector response between 0.1 and 1 A/W (typical for detector w/o attenuator)
2. Divide range and resolution by order of magnitude of detector response for detector responsive less than 0.1 A/W. For example, if detector response is 0.002 A/W, divide range and resolution specifications by 0.001/0.1 = 0.01. Maximum range 20,000 W.

RANGING: Manual or autoranging.

AUTORANGING TIME: Average 250 msec per range.

SETTLING TIME AT DISPLAY: Less than 1 second to within 2 counts on fixed range.

CONVERSION PERIOD: 170 msec.

TEMPERATURE COEFFICIENT (0°-18°C & 28°-50°C): ±(0.1 x applicable accuracy specification) per °C.

MAXIMUM COMMON MODE VOLTAGE: 30V rms, DC to 60 Hz sine wave.

ANALOG OUTPUT

Output Voltage: +1V = -10,000 counts on the A/D converter, except +100 mV = -10,000 counts on 2 nA current range.

Output Resistance: 1000Ω.

FRONT PANEL SWITCHES

POWER: On and Off.

RANGE ▼: Selects manual range and decreases the range.

RANGE ▲: Selects manual range and increases the range.

AUTO: Selects manual or autoranging.

TIME CONSTANT: Changes the effective time constant between slow, medium and fast. Does not affect analog output.

NULL: Stores or clears the dark or ambient light level photodetector current. Subsequent power readings are computed after subtracting this current from photodetector current.

LOG/LIN: Switches between linear and logarithmic display modes.

REF: Stores or clears reference level. Enter or exit ratio or dB display modes.

λ CAL ▼▲: While held, increments (decrements) the wavelength by 10 nm steps. Detector / attenuator serial number display.

λ CAL SAVE: Store the power-up wavelength and attenuator status.

ATTENUATOR: When on, includes attenuator transmission factor in detector response used to compute optical power.

BAR GRAPH: 50 segment display of value in digital display with user selectable full scale ranges of ± 5, 25, 125, 250, 1250, 2500, 12500, 25000 counts and offset control.

ZOOM ▶: Increases bar graph sensitivity.

ZOOM ◀: Decreases bar graph sensitivity.

OFFSET: Offsets the zero of the bar segment display to the value displayed on the digital display.

ZERO CHECK: Used to adjust zero on lowest range.

IEEE-488 BUS IMPLEMENTATION (Option 835-IEEE)

MULTILINE COMMANDS: DCL, SDC, GET, GTL, UNT, UNL, SPE, SPD.

UNILINE COMMANDS: IFC, REN, EOI, SRQ, ATN.

INTERFACE FUNCTIONS: SH1, AH1, T5, TE0, L4, LE0, SR1, RL1, PP0, DC1, DT1, C0, E1.

PROGRAMMABLE PARAMTERS: Zero Check, Current Range, Null, Reference Level On/Off, Wavelength, Attenuator On/Off, Log (dBm, dB), Trigger, EOI, SRQ, Status, Output Format, Terminator.

READABLE PARAMETERS: Power, Power Range, Wavelength, Status Word.

GENERAL

DISPLAYS: 4-1/2 digit backlit LCD, 0.5 " height, polarity, range, wavelength and status indication. 50 segment Analog Display with zero offset and selectable full scale ranges of ± 5, 25, 125, 250, 500, 1250, 2500, 5000, 12500, 25000 counts.

OVERANGE INDICATION: "OL" or "-OL" displayed.

CONNECTORS:
Input: BNC.
Analog Output: Banana Jacks

OPERATING ENVIRONMENT: 0-50°C, less than 70% R.H. up to 35°C; linearly derate 3% R.H./°C up to 50°C.

STORAGE ENVIRONMENT: -25°C to + 60°C.

POWER: 105-125V or 210-250V (switch selected), 90-110V available, 50-60Hz, 12VA. Optional 5 hour battery pack, Model 835-BAT.

DIMENSIONS: 216 mm wide x 89 mm high x 267 mm deep (8.5" x 3.5" x 10.5").

NET WEIGHT: 2.1 kg (4.7 lbs.)

ACCESSORIES AVAILABLE

Model 835-BAT:	Rechargeable Battery Pack
Model 835-IEEE:	IEEE-488 Interface
Model 818-SL:	Large Area Silicon Photodetector
Model 818-ST:	Beam Sampling Silicon Photodetector
Model 818-IR:	Germanium Infrared Photodetector
Model 818-SCAL:	Detector Calibration Service
Model 818-ECAL:	Extended Wavelength Range Detector Calibration Service 300 - 1100 nm.

TABLE OF CONTENTS

i. List of Illustrations iii
ii. List of Tables iv
iii. Safety Precautions v
iv. Features vi

SECTION 1 - GENERAL INFORMATION

1.1 Introduction 1
1.2 Getting Started 1
1.3 Unpacking and Inspection 3
1.4 Specifications 3
1.5 Warranty Information 3
1.6 Manual Addenda 4
1.7 Safety Symbols and Terms 4
1.8 Optional Accessories and Services 4

SECTION 2 - OPERATION

2.1 Introduction 6
2.2 Preparation for Use 6
2.2.1 Line Power 6
2.2.2 Battery Pack Power 7
2.2.3 Battery Charging 7
2.3 Tilt Stand 7
2.4 Model 835 Familiarization 8
2.4.1 Digital Display 8
2.4.2 Bar Display 9
2.4.3 Front Panel Controls 9
2.4.4 Input Connector 10
2.4.5 Analog Output Connectors 10
2.5 Error Messages 11
2.6 Environmental Conditions 11
2.7 Basic Measurements 11
2.7.1 Power-Up 12
2.7.2 Zero Check 13
2.7.3 Setting the Wavelength 13
2.7.4 Setting Attenuator Status 14
2.7.5 Power Measurements 15
2.7.6 Time Constant 15
2.7.7 Null (REL) Measurements 15
2.7.8 Ratio Measurements 16
2.7.9 Logarithmic Modes (dBm and dB) 16
2.7.10 Bar Display Zoom and Offset 19
2.7.11 Storing the Wavelength and Attenuator Status for Power-Up 20
2.7.12 Inverting Analog Output 20
2.7.13 IEEE Interface Option 21
2.8 Measurement Considerations 22
2.8.1 Detector Calibration and Accuracy 22
2.8.2 Temperature Effects 22
2.8.3 Ambient and Stray Light 23
2.8.4 Wavelength Response of Detector and Attenuator 24

2.8.5 Detector Uniformity 24
2.8.6 Detector Saturation 25
2.8.7 Attenuator Characteristics 26
2.8.8 Reflections and Interference Effects 26
2.8.9 Grounding Considerations 26
2.8.10 Changing Detectors 26

SECTION 3 - PERFORMANCE VERIFICATION
3.1 Introduction 27
3.2 Environmental Conditions 27
3.3 Recommended Test Equipment 27
3.4 Initial Conditions 28
3.5 Verification Procedure 28

SECTION 4 - THEORY OF OPERATION
4.1 Introduction 30
4.2 Overall Functional Description 30
4.3 Photodetector 30
4.4 Electronic Display Functional Description 30
4.4.1 Input Amplifier 31
4.4.2 Microcomputer and PROM 31
4.4.3 Power Supply 31
4.4.4 Model 835-BAT Rechargeable Battery Option 32

SECTION 5 - MAINTENANCE
5.1 Introduction 33
5.2 Top Cover Removal/Installation 33
5.3 Battery Pack (Model 835-BAT) Installation 33
5.4 Special Handling of Static Sensitive Devices 34
5.5 Detector/Attenuator Recalibration or Replacement 35
5.5.1 PROM Replacement Procedure 35
5.6 IEEE-488 (Model 835-IEEE) Interface Installation 35
5.7 Troubleshooting and Self Diagnostic Program 36

Section 6 - SERVICE
6.1 Introduction 37
6.2 Factory Service 37
6.3 Component Location Drawings 37

LIST OF ILLUSTRATIONS

2-1	Line Frequency Jumper	6
2-2	Model 835 Front Panel	8
2-3	Feedback Picoammeter and Signal Conditioning Circuit	21
2-4	Wavelength Response of Silicon Detector and Attenuator	24
2-5	Detector Saturation	25
3-1	Interconnection of Current Source and Model 835	28
4-1	Simplified Block Diagram	31
6-1	Exploded View of Model 835	38
6-2	Mother Board Component Location Drawing	39

LIST OF TABLES

2-1	Error Messages	11
2-2	Range, and Overload Conditions	12
3-1	Recommended Current Calibration Equipment	27
3-2	Calibration Check Table	29

SAFETY PRECAUTIONS

The following safety precautions should be observed before operating the Model 835.

This instrument is intended for use by qualified personnel who recognize shock hazards and are familiar with safety precautions required to avoid possible injury. Read the manual carefully before operating the instrument.

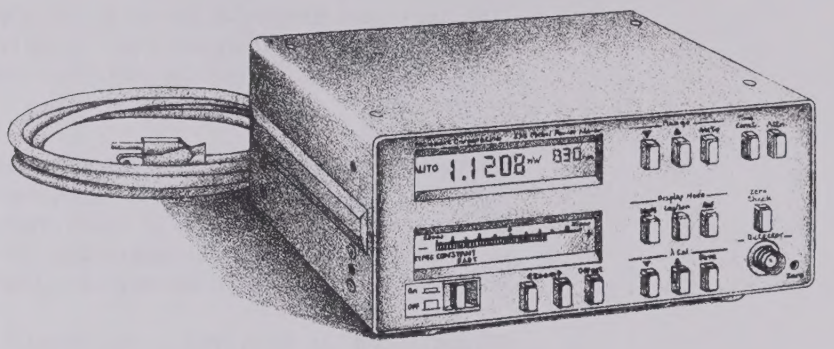
Exercise extreme caution when a shock hazard is present at the detector input. The American National Standards Institute (ANSI) states that a shock hazard exists when voltage levels greater than 30V RMS or 42.4V peak are present. **A good safety practice is to expect that a hazardous voltage is present in any unknown circuit before measuring.**

Do not exceed 30V RMS between the detector input connector and earth ground.

Inspect detector leads for possible wear, cracks, or breaks before each use. If any defects are found, replace with detector cable with one that has the same measure of safety as the ones supplied with the instrument.

Do not connect any conducting detector housing to anything that may have a voltage higher than 30V.

Model 835 Laser Pico-Watt Digital Power Meter



FEATURES:

* 4-1/2 Digit digital and 50 segment analog backlit LCD displays
* Digital wavelength response compensation
* Autoranging from 2 nW to 2 mW full scale. Up to 2W with attenuator
* Linear and Log (dBm and dB) modes
* Ref Mode displays power ratio relative to stored power reference
* Choice of individually calibrated Silicon and Germanium detectors
* Analog Ouput

OPTIONS:

* Model 835-BAT Rechargeable Battery Pack
* Model 835-IEEE IEEE-488 Computer Interface
* Model 818-FA Fiber Connector Adaptor with FP3-CA series Snap-In Fiber Connectors

Section 1

GENERAL INFORMATION

1.1 INTRODUCTION

This instruction manual contains the necessary information for operating and maintaining the Model 835 Series Laser Pico-Watt Digital Power Meter and the Model 835-BAT Rechargeable Battery Pack. This information is divided into the following sections:

1. Section 1 contains general information and provides guidelines for using this manual. Important safety information is also presented here.
2. Section 2 contains detailed operating information for the Model 835 Series Power Meters.
3. Section 3 contains the information needed to verify the electronic accuracy of the Model 835. Performance verification can be done upon the receipt of the unit or whenever the accuracy is in question.
4. For the more technically oriented user, information on theory of operation and maintenance is contained in Sections 4 and 5.
5. Section 6 contains information on factory service and component location drawings.

NOTE

The Model 835-IEEE IEEE-488 computer interface and all photodetectors come supplied with separate instruction manuals.

1.2 GETTING STARTED

Perform the following steps in sequence to quickly and safely become familiar with the basic operation of the Model 835.

1. Verify that the Model 835 was not damaged in transit, as explained in paragraph 1.3.
2. Carefully read sections on Safety Precautions, General Information, and Operation. Understand and observe the warnings found in these sections.
3. Referring to paragraph 2.2.1 (Line Power) set the line voltage switch and line frequency (if necessary) and plug the power cord into a properly grounded outlet. If the optional battery pack is installed the charge circuitry will be activated.
4. Become familiar with the controls and displays of the Model 835 as follows:
   A. Turn on the Model 835 by pressing in the red ON/OFF pushbutton. **F60** or **F50** will be briefly displayed, followed by the detector or attenuator serial number. **F60** indicates that the unit is configured to operate at a 60 Hz line frequency. **F50** indicates that the unit is configured for 50 Hz. Do NOT connect any detector yet.
   B. The **ATTENUATOR** annunciator may be on. Press the ATTN button several times. The **ATTENUATOR** annunciator will

turn on and off. While in Attenuator mode, the display readings are compensated for the optical characteristics of the attenuator. End with the **ATTENUATOR** annunciator off.

C. The meter will be in autoranging mode on power up. The **AUTO** annunciator will be displayed. To put the meter into manual ranging mode, press the AUTO pushbutton. The **AUTO** annunciator will turn off. Press RANGE ▲ to set a less sensitive range or RANGE ▼ to set a more sensitive range. Press AUTO again to return to autoranging. The wavelength of photodetector responsivity data used for power calculation will be displayed in the upper right of the digital display followed by the **nm** annunciator.

D. Press the ZERO CHECK pushbutton and note that the **ZERO CHECK** annunciator turns on. Press again to turn off.

E. The Null (**REL**) mode can be used in the linear measurement (watt) mode or the logarithm mode. The stored Null current level will be subtracted from all subsequent measurements. Press the NULL pushbutton and note that the **REL** (for relative) annunciator turns on. Press again to turn off.

F. Select logarithm mode (for decibel readings) by pressing the LOG/LIN button. The **dBm** annunciator will turn on. Press again to take the Model 835 out of the decibel mode.

G. The REF (reference) button stores the reference level to be used to calculate dB (relative) or to make ratio measurements. Press the REF button and note that the watt (**W**) annunciator turns off to indicate that the reading is a ratio. The **OL** (overload) annunciator may turn on indicating that the reference level is too small or the signal too large to give a meaningful ratio. Press the LOG/LIN button to put the instrument in logarithmic mode, then press the REF button. The **dB** annunciator will light. Press again to clear the reference level and take the instrument out of REF mode.

H. Photodetectors have response characteristics which depend upon the wavelength of the light incident upon them. Press the λ CAL ▲ (wavelength up) and hold in until the wavelength annunciator turns off. The word **PROBE** will light, and the main display will show the detector serial number. Press the ATTN button and the display will show the attenuator serial number, the **ATTENUATOR** annunciator will light, and the **PROBE** annunciator will turn off. Press the λ CAL ▼ (wavelength down) button and hold until the attenuator serial number is again displayed. Press the ATTN button again to turn the attenuator calibration factor off.

I. The λ CAL SAVE button stores the wavelength and attenuator status as power-up conditions. See paragraph 2.7.11.

J. The TIME CONST button controls the effective time constant of the displayed readings. Press and hold the TIME CONST button. The **TIME CONSTANT** annunciator on the lower display will change in a repeating **SLOW**, **MED**, **FAST** sequence.

K. The group of buttons below the bar segment display control the zero and resolution of the bar segment display. The OFFSET button sets the zero of the bar display to the digital reading

when the OFFSET button is pressed. Press the analog display OFFSET button. The **OFFSET** annunciator in the lower display should light. Press again to reset the bar display zero. The ZOOM buttons control the resolution and range of the bar display. The numbers at the end of the bar display indicate the range. Depress and hold the ZOOM out ◀ button until the number at the ends of the bar segment display is 25000. Momentarily depress the ZOOM in ▶ button. The number at the end of the display will change to **12500**. Press and hold until that number is **5.** Depress and hold the ZOOM out ◀ until the full scale range of the bar graph is ±25000 counts.

NOTE

In this manual the term "counts" refers to an increment of one in the least significant digit of the digital display. For example, if the digital display read 1.9453 mW, 1 count is 0.0001 mW. If the display reads -23.45 dB, 1 count is 0.01 dB.

Connect the detector in normal room lights and familiarize yourself with the operation of the instrument following the steps above as a guide.

When you are comfortable with the controls of the Model 835, go on and make the desired measurements using Section 2, Operation as a guide.

1.3 UNPACKING AND INSPECTION

The Model 835 Laser Pico-Watt Autoranging Power Meter was carefully inspected mechanically, electrically, and optically, before shipment. Upon receiving the Model 835, check for any obvious signs of physical damage that might have occurred during shipment. Report the damage to the shipping agent immediately. Retain the original packing materials in case reshipment becomes necessary. The following items are included with every Model 835 order:

* Model 835 Laser Pico-Watt Autoranging Power Meter
* Photodetector (some models include stand)
* Photodetector Manual and Calibration Certificate
* Model 835 Instruction Manual
* Additional Accessories and Options as included

1.4 SPECIFICATIONS

Detailed Model 835 specifications may be found immediately preceding the table of contents of this manual.

1.5 WARRANTY INFORMATION

Warranty information may be found on the inside front cover of this manual. Should it be necessary to exercise the warranty, contact your Newport representative or the factory to determine the correct course of action. Newport Corporation maintains offices in the United States, West Germany, and England. Information concerning the application,

operation, or service of your instrument may be directed to any of these locations. Check the back cover of this manual for addresses.

1.6 MANUAL ADDENDA

Information concerning improvements or changes to the instrument which occur after the printing of this manual will be found on the addendum sheet included with this manual. Be sure to review these changes before attempting to operate or service the instrument.

1.7 SAFETY SYMBOLS AND TERMS

The following safety symbols and terms are used in this manual or found on the Model 835.

The symbol ⚠ on the instrument indicates that the user should refer to the operating instructions in this manual.

The **WARNING** heading in this manual explains dangers that could result in personal injury or death.

The **CAUTION** heading in this manual explains hazards that could damage the instrument.

1.8 OPTIONAL ACCESSORIES AND SERVICES

The following accessories can be used with the Model 835.

Model 818-SL Silicon Photosensor -- A 1 cm^2 aperture silicon photodiode packaged to facilitate mounting and accept fiber adapters. Useful spectral range 400-1100 nm. Includes detachable attenuator. Extended range detectors available.

Model 818-ST Silicon photosensor -- A handheld silicon photosensor in a very thin package especially useful for measuring power in hard to reach places.

Model 818-IR -- A 3 mm diameter Germanium photosensor with a post mountable housing capable of accepting filters and fiber adapters. Useful spectral range 800-1800 nm.

Model 883 Attenuator -- A replacement attenuator for use with the Model 818-SL photosensor.

Model 835-BAT Rechargeable Battery Pack -- Provides a minimum of 5 hours operation from full charge, recharges within 10 hours and is field installable.

Model 835-IEEE Computer Interface -- IEEE-488 standard interface option provides isolated data output and instrument control. Switch-selectable talk only or addressable modes. Mounts within and is powered by the Model 835.

Calibration - Newport maintains a National Bureau of Standards (NBS) traceable spectrophotometric calibration facility. Photodetectors may be recalibrated on a fee for service basis. In addition, special calibration services can be arranged. Contact Newport for details.

SECTION 2

OPERATION

2.1 INTRODUCTION

This section contains the information needed to prepare and operate the Model 835 as a power meter. Bench operation consists of using the Model 835 to perform basic optical power measurements. Using the instrument to compensate for dark current and ambient light, as well as making ratio and logarithmic (dBm, dB) measurements, is also covered. The capabilities of the Model 835 can be enhanced with the addition of then Model 835-IEEE interface. IEEE-488 computer interface operation is covered in the Model 835-IEEE Instruction Manual.

2.2 PREPARATION FOR USE

2.2.1 Line Power

The Model 835 is provided with a three-wire line cord which mates with third wire grounded receptacles. Connect the instrument to AC line power as follows:

1. Set the LINE VOLTAGE switch on the back of the instrument to correspond to line voltage available. Ranges are 105-125V or 210-250V 50/60Hz AC. If the Model 835 is ordered with the 90-100V operation option, a label on the back panel will indicate that the meter is configured for 100V operation.

CAUTION

Connect only to the line voltage selected. Application of incorrect voltage can damage the instrument.

2. If 50 Hz operation is desired, open the top cover of the instrument (see paragraph 5.2), and connect the line frequency jumper as shown below. Units are normally shipped configured for 60 Hz operation as indicated by the F60 display immediately after power-up.

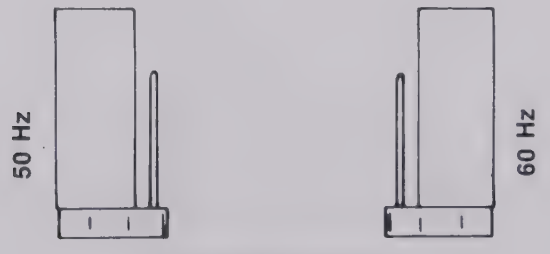


Fig. 2-1 50/60 Hz Selection Jumper

3. Plug the power cord into a properly grounded outlet.

WARNING

Ground the instrument through a properly grounded receptacle before operation. Failure to ground the instrument can result in severe injury or death in the event of short circuit or malfunction.

NOTE

Although the Model 835 is specified at 50 Hz and 60 Hz, the instrument may be operated at 400 Hz and 440 Hz. Add 10 counts to instrument specifications under this condition.

2.2.2 Battery Pack Power

The Model 835 may also be operated from rechargeable sealed nickel-cadmium batteries contained in the optional Model 835-BAT Rechargeable Battery Pack. A fully charged battery pack will operate the Model 835 for five hours. The **BAT** annunciator will turn on when the battery charge is insufficient to maintain accurate readings. Refer to Section 5, paragraph 5.3 for installation procedures.

2.2.3 Battery Charging

After the Model 835-BAT Battery pack is installed in the Model 835 it can be charged and recharged as follows:

1. Connect the instrument to line power as described in paragraph 1.2.
2. With the power switch off, the battery charge circuitry is automatically energized to charge the battery at the maximum rate. When the battery pack is first installed, or if it is completely discharged, allow it to charge for ten hours.

NOTE

For maximum battery efficiency only charge the battery pack after it has become discharged and only charge until it is fully charged (10 hours). Continuous charging over long periods of time will not damage the batteries but, useful life will gradually decrease. This loss is not permanent and may be restored by cycling the battery pack through several complete charge/discharge cycles. The battery pack is capable of 500 to 1000 charge/discharge cycles before replacement is needed.

Do not make measurements with the **BAT** annunciator on as the readings may be erroneous.

3. When the Model 835 is in use on line power, the battery charger maintains a trickle charge on the battery pack.

2.3 TILT STAND

The Model 835 is equipped with a tilt bail which makes it possible to elevate the instrument to a convienent viewing position. To elevate the instrument pull the bail on the bottom of instrument out until it locks in position.

2.4 MODEL 835 FAMILIARIZATION

The following paragraphs and Figure 2-2 provides a brief description of the display, front panel controls and connectors.

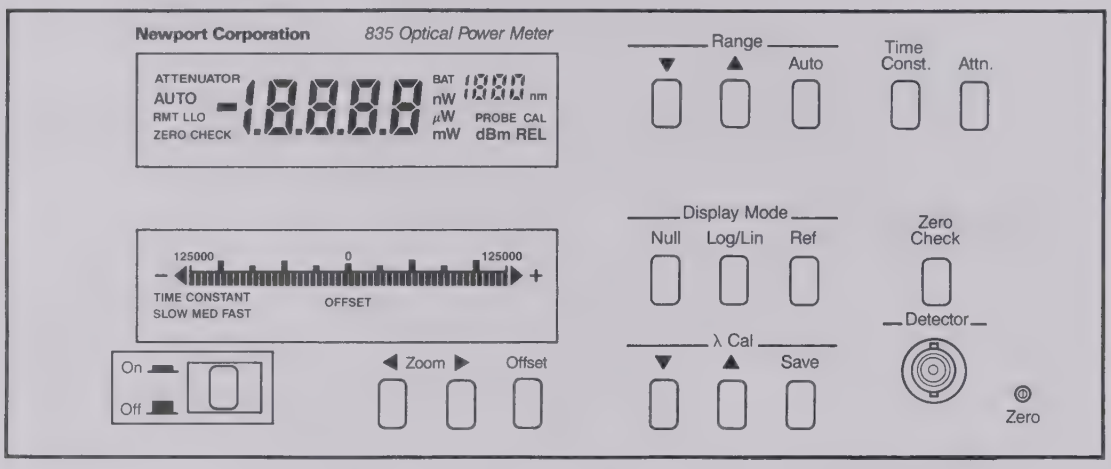


Fig. 2-2 Model 835 Front Panel

2.4.1 Digital Display

The Model 835 has a 4-1/2 digit backlit liquid crystal display (LCD). The minus sign is displayed. The plus sign is implied by the absence of the minus sign. The following annunciators are displayed on the LCD.

BAT - Low battery indicator for the Model 835-BAT.

nW, µW, mW, or W -- Nanowatts, microwatts, milliwatts, or watts display range selected.

dBm, dB -- Decibels relative to 1 mW (dBm) or decibels relative to user set level (dB) selected.

When neither watts or decibels displayed -- Value displayed is a linear ratio referenced to user set power.

RMT (Remote) -- Model 835 being controlled over the IEEE-488 bus (Model 835-IEEE installed).

AUTO - Autorange selected.

REL - Null selected.

ZERO CHECK – Zero Check selected.

nm -- Follows wavelength used to determine detector responsivity used to compute optical power from detector photocurrent. If NOT displayed, detector or attenuator serial number is displayed.

ATTENUATOR -- Indicates attenuator selected. When in serial number display mode, indicates that attenuator serial number is displayed.

PROBE -- Indicates detector serial number is displayed.

CAL -- Model 835 in current calibration mode. This is normally a factory procedure.

2.4.2 Bar Display

The lower LCD display is a 50 segment bar with variable resolution. The zero of the analog display is at the center of the bar, and is marked 0.

Numbers at ends of the bar -- Above each end of the bar numbers are displayed which indicate the full scale range of the bar segment. Full scale is ±5, 25, 125, 250, 500, 1250, 2500, 5000, 12500 or 25000 counts.

OFFSET -- Indicates that the zero of the bar graph has been offset from the digital display zero.

TIME CONSTANT (SLOW, MED, or FAST) -- Indicates instrument response time constant selected.

2.4.3 Front Panel Controls

ON/OFF -- Pressing this button turns the Model 835 on. Releasing (out) this pushbutton turns the instrument off.

ZERO CHECK and ZERO -- This pushbutton and trimpot are used to zero the instrument's internal effects.

ATTN. -- This button is used indicate that the attenuator is used with the detector. Press again to indicate that the attenuator is not used.

RANGE BUTTONS

▼▲-- Pressing either of these buttons sets the instrument to manual range. When ▲ is pressed, the full scale range of the instrument is increased. When ▼ is pressed, the range is decreased. Ranges set are current ranges and are ±2 nA to ±2 mA full scale. Full scale power ranges will depend upon the detector response and are wavelength dependent.

AUTO -- Pressing the AUTO button when the instrument is in manual ranging sets the instrument to autoranging. When the instrument is already in autoranging, the instrument is set to manual ranging without changing the range.

TIME CONST -- Pressing this button changes the effective time constant between slow, medium, and fast.

NULL -- Press this button to store the dark or ambient light level photodetector current. Subsequent measurements will be displayed with this current subtracted before conversion to optical power. The REL an-

nunciator will light when Null is on. Pressing this button again shuts Null off.

LOG/LIN -- Press this button to select the logarithmic display modes. The displayed power is expressed as decibels relative to 1 milliwatt when the **dBm** annunciator is lit, and as decibels relative to a user stored reference level when the **dB** annunciator is lit.

REF (Reference) -- Press to store reference power. In linear mode, the display is the ratio of the power with respect to the stored reference power. Power annunciator (W) turns off. In log mode, the display changes to dB referenced to stored power.

λ CAL:

▼▲Wavelength up/down -- Changes the wavelength used in the detector response calculation. Press momentarily to change by 10 nm. Hold in to scan wavelengths. At ends of wavelength range, detector serial number is displayed with the annunciator **PROBE** lit. If attenuator is on, attenuator serial number is displayed with only the annunciator **ATTENUATOR** lit.

SAVE -- Press to save wavelength value and attenuator status as initial conditions on next power up. **Stor** annunciator lights briefly, then instrument continues to make measurements.

BAR GRAPH DISPLAY CONTROLS:

The bar graph input is the digital display. Therefore, range changes affect the bar graph display. To avoid unexpected range changes, use manual ranging.

Zoom ◀, ▶ -- Changes the resolution of the bar graph. ▶ increases segment resolution and decreases bar graph range. ◀ decreases segment resolution and increases bar graph range. Full scale bar graph range can be ±5, 25, 50, 125, 250, 500, 1250, 2500, 5000, 12500, 25000 counts corresponding to individual segment resolution of 0.2, 1, 2, 5, 10, 20, 50, 100, 200, 500, and 1000 counts on the digital display.

OFFSET -- Press this button to offset zero of bar segment display to the value presently displayed on the digital display. Press again to clear offset.

2.4.4 Input Connector

The input connector is a standard BNC type with a floating outer shell.

2.4.5 Analog Output Connectors

A voltage level that is proportional to the incoming current can be monitored using the analog output banana jacks located on the rear panel. Note that range changes, even on autoranging, will change the constant of proportionality (gain) of the output signal. Range changes which are

not apparent on the front panel display may occur if the instrument is in autorange mode.

2.5 ERROR MESSAGES

Table 2-1 lists the error messages associated with basic front panel operation. Note that the instrument has a number of other messages that are discussed in the appropriate sections of this manual.

Table 2-1 Error Messages

Display	Message	Comments
0000	RAM Error	Model 835 Locks up. See Section 5 for troublshooting information.
cErr	Calibration Error (NVRAM Failure)	Model 835 locks up, but operation can be restored by pressing any one of the momentary pushbuttons. If restored, calibration is invalid as indicated by flashing "CAL" annunciator. Readings are still approximately correct. See Section 5 for troubleshooting information.
OL	Overrange	1. Overrange input applied to the Model 835. 2. Ratio is too large
-OL	Overrange	Logarithm of negative power

2.6 ENVIRONMENTAL CONDITIONS

All measurements should be made at ambient temperature within the range 0 °C to 50 °C, and with a relative humidity of 0% to 70% up to 35 °C. For instruments operating above 35 °C derate humidity specification 3% per °C up to 50 °C. If the instrument has been subjected to extremes of temperature, allow sufficient time for internal temperatures to reach environmental conditions. Typically, it takes one hour to stabilize a unit that is 10 °C (18 °F) out of specified temperature range.

The photodetector temperature should be at or below the calibration temperature.

NOTE

The photodetectors supplied with this instrument have characteristics which are temperature dependent. Dark noise and detector response change with temperature. See the appropriate detector manual.

2.7 BASIC MEASUREMENTS

Basic measurement techniques for using the Model 835 to measure DC optical power are covered in the following paragraphs. Also included is the operation of the bar graph display, making measurements in decibels (dBm and dB), and using the Null and Reference functions. A summary of range, electrical accuracy and overload conditions of the instrument is given in Table 2-2. Instrument drift will depend upon the detector used.

In general, absolute accuracy is limited by the accuracy of the detector calibration and environmental factors affecting the detector. See the appropriate detector manual for this information.

Table 2-2 Range Electrical Accuracy and Overload Conditions

Power Range[1]	Maximum Reading[1,2]	Current Range[1]	Accuracy[3] ±(%Rdg +%Full Scale) 18°C - 28°C
2 nW	1.9999 nW	2 nA	0.4 + 0.2
20 nW	19.999 nW	20 nA	0.4 + 0.05
200 nW	199.99 nW	200 nA	0.2 + 0.05
2 µW	1.9999 µW	2 µA	0.15 + 0.05
20 µW	19.999 µW	20 µA	0.1 + 0.05
200 µW	199.99 µW	200 µA	0.1 + 0.05
2 mW	1.9999 mW	2 mA	0.1 + 0.05

Notes:
1. Assuming detector response in the range 0.1 to 1.0 Amp/Watt. For detector response smaller than 0.1 Amp/Watt, divide power range and maximum reading by the ratio of the order of magnitude of the detector response to 0.1. For example, if the detector response is 0.03 Amp/Watt, divide power range and maximum reading by 0.01/0.1 = 0.1, so the ranges will be from 20 nW to 20 mW.
2. Power above the maximum will result in "OL" display.
3. Electrical accuracy depends on current range. Detector calibration accuracy usually limits reading accuracy.

WARNING

Before operating the Model 835, observe the safety precautions found preceding Section 1. Failure to observe these and other safety precautions found in this manual could result in severe injury or death.

WARNING

Do not exceed 30V RMS between input low and power line ground or a shock hazard will result. Also, current inputs that exceed 3 mA may be erroneously displayed as an on-scale reading.

2.7.1 Power-Up

NOTE

The software revision of the Model 835 can be displayed upon power-up by running the diagnostic program. See Section 5, paragraph 5.7, for more information.

Turn on the Model 835 by pressing the ON/OFF switch. The following will occur automatically:

1. Reset -- **F60** or **F50** will be briefly displayed before displaying the detector serial number. **F60** (**F50**) indicates that the unit is configured for 60 Hz (50Hz).

2. RAM Test -- If this test fails the Model 835 will lock up with **F60** or **F50** displayed.
3. NVRAM test -- This test determines if the instrument analog electronics, not the detector response calibration, are properly read from the NVRAM. If this test fails the display will show the error message **cErr**.
4. Serial number display -- The detector serial number will be briefly displayed. If the attenuator is on, the attenuator serial number will be displayed with the annunciator **ATTENUATOR** lit. Verify that the detector and attenuator attached to the instrument has the same serial number as the number displayed to ensure calibration accuracy.
5. Begin measurement -- The instrument will use the wavelength and attenuator status values last stored with the λ CAL SAVE button. Autoranging will be on.

Refer to Table 2-1 for more information pertaining to error messages.

CAUTION

During power up and power down, using AC line or battery pack, a current surge (5mA, 5V maximum) can appear at the INPUT of the Model 835. Protect the photodetector by making circuit connections only after turning on the Model 835. Disconnect the photodetector before turning off the Model 835.

2.7.2 Zero Check

The instrument should be properly zeroed (after one hour warm-up) before making any current measurements. Upon pressing ZERO CHECK, the instrument will automatically enter the current display mode. Set manual range mode, and range to the most sensitive range (2 nA full scale). Display will read **.xxxx nW**. To check or adjust zero, proceed as follows:

1. Write down instrument settings to restore after finishing checking the zero. Null, Log, and Ref will automatically be turned off by pressing ZERO CHECK.
2. Press the ZERO CHECK button.
3. Adjust the zero level trimpot via the access hole on the front panel for a zero indication on the digital display.
4. Press the ZERO CHECK button again to turn off.
5. Restore instrument settings as desired to continue measurement.

2.7.3 Setting the Wavelength

In order to obtain accurate optical power measurements, it is necessary to set the instrument calibration wavelength to the wavelength of the light incident upon the photodetector. The instrument calibration wavelength is indicated in nanometers in the upper right hand of the digital LCD display and is followed by the annunciator **nm**. Upon power-up, the wavelength will be set to the value last stored by pressing

the λ CAL SAVE button. To change the wavelength:

1. Determine the wavelength of the light being measured to the nearest 10 nm. If the source is broadband, use a value near the center wavelength of the light, or the wavelength of greatest intensity.
2. If the wavelength is greater than the value displayed, depress the λ CAL ▲ button, and hold until the desired wavelength is reached.
3. If the wavelength is lower than the value displayed, depress the λ CAL ▼ button, and hold until the desired wavelength is reached.

Notes:

1. Momentarily depressing the λ CAL ▼ or ▲ buttons will increase or decrease the calibration wavelength by 10 nm. Wavelength will continue to change as long as the wavelength button is held in.
2. Different detectors are sensitive over different wavelength ranges. See the appropriate detector manual and calibration data to determine the range of wavelengths for which the detector connected to the instruments can be used. The calibration constants stored in the instrument span only the wavelength range appropriate for the detector, and can be determined by following Note 3 below.
3. Depressing and holding either the λ CAL ▲ or ▼ buttons until the wavelength range of the detector is exceeded will cause the detector serial number and the **PROBE** annunciator to be displayed on the main digital display, and the wavelength annunciator to turn off. If **ATTENUATOR** is on, the attenuator serial number will be displayed instead, and the **PROBE** annunciator will be off.
4. To stop the serial number display, press λ CAL ▲ . If the instrument remains in serial number display mode, press λ CAL ▼ . Use the λ CAL ▲ and ▼ buttons to set the desired calibration wavelength as above.
5. If the instrument calibration wavelength cannot be set to within 5 nm of the desired value, then the detector/PROM combination being used is not appropriate for this measurement. See Section 5 for Detector/PROM replacement.

2.7.4 Setting Attenuator Status

Some Newport photodetectors are provided with calibrated attenuators. The calibration constants for an attenuator and detector combination are stored in the Model 835. To measure optical powers above the saturation limit of the photodetector (see appropriate photodetector manual), use an attenuator. When the attenuator is selected the following occurs:

1. The **ATTENUATOR** annunciator is displayed.
2. The detector calibration constants are computed including the effects of the attenuator.

If the attenuator is subsequently removed, the ATTN button should be pressed to turn the attenuator off. Subsequently, all displayed values will be computed using wavelength calibration constants computed for the detector without the attenuator.

NOTE

The transmission characteristic of each attenuator is slightly different, therefore the user must be careful to use ONLY the attenuator and detector pair with the same serial numbers as the particular Model 835 PROM is calibrated for.

2.7.5 Power Measurements

1. Zero the instrument as described in paragraph 2.7.2
2. Select autoranging or manually range to a desired range for the expected power level.
3. Connect the detector to the INPUT connector on the front panel. A summary of range, and input overload information is given in Table 2-2. Detector calibration accuracy and drift information is supplied with the detector.
4. Read the optical power on the digital display. Overrange is indicated by an **OL** message.

2.7.6 Time Constant

Three time constants are available for operating the Model 835 : slow, medium, and fast. To select the desired time constant:

1. Press the TIME CONST button until the **TIME CONSTANT** annunciator on the lower LCD indicates that the desired time constant is set.

2.7.7 Null (REL) Measurements

When NULL (relative) is selected with an on-scale reading on the display, the following occurs:

1. The **REL** annunciator is displayed.
2. The next current reading is stored.
3. The stored current is then algebraically subtracted from all subsequent current readings before the optical power computation.

The primary purpose of NULL is to allow the user to take accurate readings even when significant amounts of dark current or ambient light are present. The conversion factor from current to optical power depends upon the wavelength of light. For this reason, the current and NOT the optical power is stored and subtracted from subsequent current readings prior to conversion to optical power.

A Null current offset can be established for the linear measurement mode or the decibel measurement mode, and is effective for both modes. Changing modes or wavelengths will not affect a Null level, however, if NULL is pressed again, the Null current offset will be cleared and cannot be recalled.

It is important to note that the use of Null in manual range mode may reduce the dynamic range of the measurements by that current level. For instance, assume that the Null current offset is +1.5 μA and the Model 835 is manually set to the 2 μA full scale range. Also, assume that

the detector response is 0.5 amp/watt. The maximum positive displayed reading that could be displayed before overranging would be 1.9999 µW. The displayed power is then (1.9999-1.5)/0.5 = 0.9998 µW . Thus, the dynamic range of measurement is -1.9999 µW to +0.9998 µW compared to the normal -1.9999 µW to +1.9999 µW with the same detector response. The dynamic range of the measurement has been reduced by 1 µW (0.5 µA). The effects on dynamic range can be reduced by selecting a higher range or using autorange. The large dynamic range of the Model 835 allows measurements to be made with null current offsets of 90% or more of full scale which are still accurate and precise.

2.7.8 Ratio Measurements

When the ratio mode is selected by pressing the REF button in linear mode with an on-scale reading on the display the following occurs:

1. The power annunciator (**nW, µW, mW,** or **W**) is turned off.
2. The next power reading is stored.
3. The stored reading is then algebraically divided into all subsequent readings and displayed.

See paragraph 2.7.9 for the action when REF is pressed in Log mode. Changing modes to Log after pressing REF will clear the REF level.

The method used is calculate the ratio is shown below:

RATIO = $((I - I_d)/\text{Response})/\text{Stored Power}$

where

I = Photodetector current
I_d = Stored Null current (see paragraph 2.7.7)
Response = Response in amps/watt of the detector, or detector and attenuator, at the wavelength currently displayed in the LCD
Stored Power = Displayed power value stored when REF button was pressed.

Note that this method of computation allows accurate optical power ratio measurements to be made with the reference and measurement wavelengths to be different.

2.7.9 Logarithmic Modes (dBm and dB)

The Model 835 can make logarithm measurements referenced to a 1 mW power level or to other power levels with the use of the REF feature.

The basic procedure for using the Log mode is to select autorange and press the LOG button (**dBm** annunciator comes on). To get out of Log mode, press the LOG button again. The **dBm** annunciator will turn off, and one of the watt annunciators will turn on.

Because the logarithm of a negative number is undefined, **-OL** is displayed if the logarithm of a negative number is attempted.

NOTE

Log measurements should always be made on the lowest possible range (without overranging). Readings on high ranges will not allow optimum calculations of the logarithm. When in doubt, use autorange.

1. Log measurements with a 1 mW Reference (dBm): The Log measurement mode displays the absolute value of 10 times the logarithm (base 10) of the input current referenced to 1 mW. The following equation illustrates this relationship:

   dBm reading = 10 Log (Net Applied Power/ 1 mW)
   = 10 Log (((I-I_d) /Response)/1 mW)

Using this reference power, the dBm reading span is from -100.0 to +33.00 dBm (0.1 pW to 2 W).

The following examples compute the expected Log readings for various power levels applied to the Model 835.

A. 1 nW (0.5 nA with detector response of 0.5 A/W)

Power = (0.5 nA/ 0.5 A/W) = 1 nW
Log reading = 10 Log (1 nW/1mW)
Log reading = -60.00 dBm

B. 1 W (1 mA with detector and attenuator response of .001 A/W)
Power = (1 mA / 0.001 A/W) = 1000 mW = 1 W
Log reading = 10 Log (1000 mW/ 1 mW)
Log reading = +30.00 dBm

C. 0.5 µW (0.5 µA - 0.25 µA stored null current offset and detector response of 0.5 A/W)

Power = ((0.5 - 0.25 µA)/0.5 A/W) = 0.5 µW
Log reading = 10 Log (0.5 µW/ 1 mW)
Log reading = -33.01 dBm

To make dBm measurements (relative to 1 mW optical power) without Null current offset, proceed as follows:

A. Zero the instrument, if required, as described in paragraph 2.7.2.
B. Select AUTO range on the Model 835
C. Connect the source to the Model 835
D. Press the LOG/LIN button
E. Take the dBm reading from the display.

To make dBm measurements (relative to 1 mW optical power) with Null current offset, proceed as follows:

A. Follow steps A to C above

B. Block the optical signal to the detector (for example, block the laser beam)

C. Press the NULL button. Display should read approximately zero, but will fluctuate depending upon the variations in the amount of light irradiating the detector as well as with detector dark current fluctuations.

D. Illuminate the detector with the optical signal to be measured.

E. Press the LOG/LIN button

F. Take the dBm reading from the display

Note : When using Log mode with Null current offset, the signal after the subtraction of the stored Null offset may be negative. In this case, **-OL** will be displayed since the logarithm of a negative number is not defined. This will be automatically cleared when the signal becomes positive.

2. Log measurements using other reference powers (dB):

Decibel (dB) measurements, referenced to other optical power levels, can be read directly from the display of the Model 835 by utilizing the Ref feature.

To make dB measurements referenced to another power level, proceed as follows:

A. Follow either sequence (A-D or A-F) above.

B. After pressing the LOG/LIN button, illuminate the detector with the reference signal.

C. Press REF to select reference mode. The following will occur:

   1. The **dB** annunciator is displayed.
   2. The next power reading (in dBm) is stored.
   3. The stored reading (in dBm) is then algebraically subtracted from all subsequent readings (in dBm) and displayed.

D. The Model 835 is now set up to make decibel (dB) measurements referenced to the stored power level. Simply input the power to be measured and take the reading from the display.

Decibel readings may be positive or negative. **OL** will be displayed if the input current exceeds 2 mA, or if the optical power exceeds the maximum power for the detector or detector attenuator combination (in autoranging), or the range selected (in manual ranging). **-OL** will be displayed if the input current is less than the stored Null current offset.

Example:

1. Signal = 2 mW
   Press LOG/LIN
   Display = +3.01 dBm
   Press REF.
   Display = +0.00 dB
   Signal = 0.5 mW
   Display = -6.02 dB

2.7.10 Bar Display Zoom and Offset

The Model 835 includes a 50 segment bar display with zoom and offset controls to provide a qualitative method to observe changes in the signal level. The bar display functions like an analog meter with variable range and zero offset. The display is driven by the digital display value, and works in both logarithmic and linear modes. The zoom control allows the user to set the resolution of the display, while offset allows the user to offset the bar display and digital display zeros.

NOTE

When using the bar graph display, setting the instrument to manual ranging is often a convenient method to avoid unexpected jumps in the bar display due to range changes.

OFFSET: When offset is selected, the following occurs:

1. The bar segment display **OFFSET** annunciator is displayed.
2. The value of the digital display is stored.
3. The value used to drive the bar display segments is obtained by subtracting the stored value from all subsequent digital display readings.

Offset may be turned off by pressing the OFFSET button again.

ZOOM : The ZOOM ◀ and ▶ buttons control the range and resolution of the bar segment display. Full scale range of the display is selectable from **±5, 25, 50, 125, 250, 500, 1250, 2500, 5000, 12500,** or **25000** "counts". See Figure 2-2 for a drawing of the analog display. The range is displayed at either end of the bar. See the Note following section 1.2 paragraph K for an explanation of the term "count."

At the ends of the bar segment displays, two arrows are used to indicate underflow and overflow. The Underflow Arrow ◀ will turn on if either of two conditions is met:

1. The digital display value is too small to show within the range of the analog display. To display an underflowed signal, press ZOOM ◀ to increase the range of the bar segment display, or press OFFSET once or twice to reset the bar segment display zero to the digital display value.
2. **-OL** is displayed in the digital display.

The Overflow Arrow ▶ will turn on if either of two conditions is met:

1. The digital display value is too large to show within the range of the analog display. To display an overflowed signal, press ZOOM ◀ to increase the range of the bar segment display, or press OFFSET once or twice to reset the bar segment display zero to the digitial display value.
2. **OL** is displayed in the digital display.

The **MED** time constant is designed specifically to be used in conjunction with the bar display.

2.7.11 Storing the Wavelength and Attenuator Status for Power-Up

When λ CAL SAVE is pressed, the following occurs:

1. The current wavelength is stored in non-volatile memory.
2. The attenuator status is stored. If the **ATTENUATOR** annunciator is on, Attenuator On is stored. If the annunciator is off, Attenuator Off is stored.
3. The **Stor** annunciator lights briefly.
4. The instrument returns to normal operation

The stored values are recalled whenever the Model 835 is powered-up.

2.7.12 Inverting Analog Output

Two banana jacks, accessible from the rear panel, permit monitoring or recording of the output from the current -to-voltage converter within the Model 835. Since the Model 835 is based on a feedback ammeter, as shown in Figure 2-3, the input current is forced through the feedback resistor and an inverted output voltage is developed by the operational amplifier. The feedback (range) resistors are selected such that voltage for an on-scale reading on the 2 nA range will be between zero and ±200 mV. The output voltage for the rest of the ranges will be between zero and ±2V. Here, range refers to the full-scale current range.

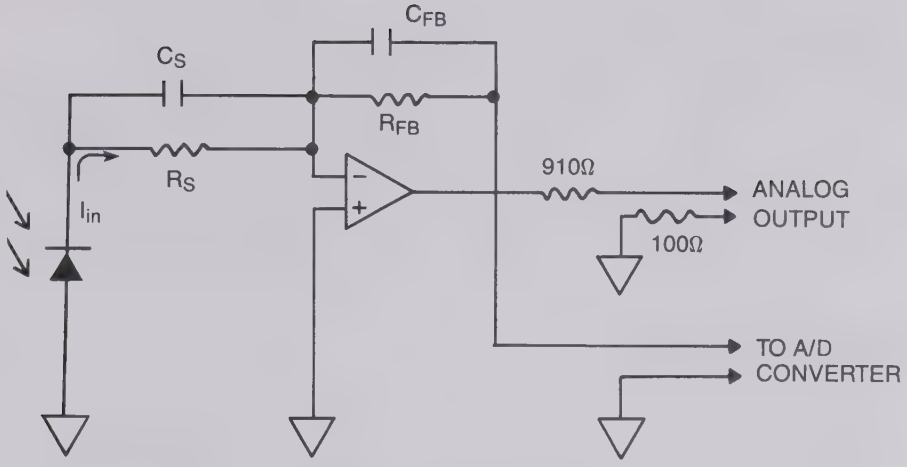


Fig. 2-3 Feedback Picoammeter and Input Signal Conditioning Circuit

NOTE

The analog output is direct current-to-voltage conversion of the input current. It is NOT directly related to the digital display, and hence is NOT dependent upon the wavelength, attenuator status, or the mode of the instrument (dB, Reference, etc.) or time constant.

The analog output is protected up to 20V RMS and during an input current overload the analog output is clamped to a maximum voltage swing of approximately ±4V. Although protected up to 20V to prevent instrument damage, a voltage applied to the analog output could cause an erroneous display, rather that the **OL** message.

Since the output of the current-to-voltage converter is bipolar, the inverting analog output can also be used to measure low frequency AC power which falls within the specified analog rise time. The inverting analog output resistance is 1.01 kΩ ; 910Ω in series with the signal leads and 100Ω in series with the ground lead.

Typical Analog Output Accuracy:
Nonlinearity: < 0.1% full scale
Gain Accuracy : ±1%
Output Resistance : ±5%

2.7.13 IEEE Interface Option

The Model 835-IEEE Interface Option is available for the Model 835. The interface allows computerized data acquisition and control of the Model 835. Detailed operating instructions for the IEEE interface are found in the Model 835-IEEE Interface Instruction Manual supplied with the interface or available from Newport Corporation.

2.8 MEASUREMENT CONSIDERATIONS

This section describes effects of detector and attenuator characteristics, optical and electrical considerations, environmental conditions, and changing detectors. The accuracy of the Model 835 is generally limited by the accuracy of the detector calibration. Making accurate measurements of optical power is dependent upon controlling the environmental conditions, specifically temperature and illumination conditions, and understanding the factors that affect power measurement.

2.8.1 Detector Calibration and Accuracy

Newport Corporation calibrates its photodetectors using secondary standards directly traceable to the United States National Bureau of Standards. At the present time, not all wavelengths are covered by optical power standards at the power levels appropriate to the photodiode based sensors. Since the details and accuracy of the calibration procedure vary with each photodetector model, a more detailed description of the calibration restrictions is supplied with each individually calibrated photodetector. Some Newport photodetectors are supplied with typical response curves and have not been individually calibrated.

In general detector, calibration accuracy is $\pm$3% to 10% in absolute terms, and varies with wavelength. Each detector will have some variations in the response over different sections of the surface. This is caused by variations in the semiconductor material. Therefore, for the most reproducible measurements, light should illuminate the detector as uniformly as possible.

CAUTION

AVOID FOCUSING onto the detector surface. Inaccurate readings and possible detector damage may result.

Individual detectors change with time, especially in the ultraviolet and should be returned for recalibration at 1 year intervals to assure confidence in the accuracy of the measurement. For the most reproducible measurements, the same detector should always be used for measurements which are to be directly comparable.

2.8.2 Temperature Effects

Photodiode characteristics are significantly affected by temperature. Typically, at longer wavelengths, detectors increase in sensitivity at longer wavelengths with increasing temperature. However, the detector/amplifier combination noise increases exponentially with temperature. With silicon photodetectors, this is generally on the order of a few picoamps at temperatures near room temperature. With uncooled germanium detectors, however, this drift is typically 1,000 to 10,000 times larger, on the order of a few nanoamps. These drifts can be nulled by covering the detector and pressing NULL. However, since the current drift changes with time, the Null should be set just prior to any measurements.

If the detector temperature is constant, sensitivity changes are significantly reduced. In addition, if detectors are cooled, noise will decrease. For the most accurate measurements, particularly with germanium detectors, the user should cool the detector to approximately 0°C, and to control the temperature of the detector to approximately ±1°C.

Since different detectors differ significantly in their characteristics, consult the appropriate detector manual for information about the details of the detector you are using.

2.8.3 Ambient and Stray Light

Ambient and stray light striking the detector will be measured by the Model 835, and should be considered when making careful measurements. Ambient light can be distinguished from dark current by turning off or blocking the source and covering the detector face with opaque material, such as a piece of black rubber or metal. Using a hand to cover the detector surface is not advised because the human hand emits a significant amount of infrared radiation, and is at a temperature significantly different from ambient. Particular care should be taken with infrared sensing detectors. With the detector properly covered, take a reading on the power meter. This is the dark current. Press NULL to offset the dark current. Next, remove the material which is covering the detector face and take another reading. This reading is the ambient light level. To make measurements with this background eliminated, press NULL twice. The meter should read approximately zero. Turn the source on and make measurements which are now corrected for dark currents and ambient light.

NOTE

Changes in ambient light levels can occur from such factors as turning room lights on or off, or by moving people or equipment. To check if the variations in ambient light are affecting the measurements, set the Model 835 on MANUAL ranging on the range which will be used for taking actual measurements. Press NULL twice to null dark currents and ambient light. Monitor the display for some time. If the display changes by more than the fluctuations in dark current, then special care in shielding the detector from ambient light is required.

The effects of ambient and stray light can be minimized by using the Model 818-FA Fiber Adapter Holder with the appropriate FP3-CA series fiber adapter when measurements of power in fiber optics are being made. If free space beam measurements are desired, using the Model 883 Attenuator will reduce stray light, and often improve the ratio of signal to ambient. Wavelength specific filters, such as optical cutoff, bandpass, or spike filters can also be used if the signal wavelength spectrum permits. Other techniques to reduce stray light include using apertures, placing the detector in a box or other housing to shield the surface from light which is not coming from the source, and turning off room and other lights.

2.8.4 Wavelength Response of Detector and Attenuator

All photodiode detectors have a response which varies with the wavelength of light which is incident upon the detector. The response is measured in amps/watt, and is typically between 0.1 and 0.6 amps/watt. A typical response curve for the Model 818-SL silicon detector is shown in Figure 2-4.

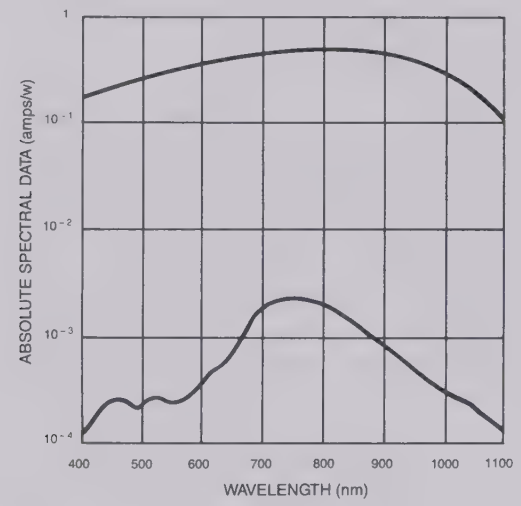


Fig. 2-4 Wavelength Response of Silicon Detector (upper curve) and Detector & Attenuator (lower curve)

The Model 835 Laser Pico-Watt Digital Power Meter measures the photodetector current, and converts the signal to an optical power by dividing the current by the response of the detector. The detector response as a function of wavelength is stored in a table in the Model 835, and the appropriate value is chosen using the wavelength set by the user. If the spectral source is broader than 10 nm, a choice must be made as to which wavelength will give the best reading. Usually this wavelength will be near the center of the optical spectrum of the source. In the central portion of the detector spectral response curve, the response varies slowly as a function of wavelength. However, near the minimum and maximum wavelengths where the detectors are sensitive, the fractional detector response can change by 1% per nanometer. In addition, attenuators also have a spectral response which is typically different from the detector response. Newport Corporation detectors are supplied with information showing detector response characteristics. Please see the information included with the detector used with the Model 835.

2.8.5 Detector Uniformity

The response of the detectors vary slightly over the detector surface. This is a result of small non-uniformities in the semiconductor composition and fabrication process. Typical non-uniformities are a few percent peak to peak for different 1 mm^2 areas on the detector surface. To reduce the effects of detector non-uniformity on measurement accuracy, illuminate as much of the detector surface as possible with the optical signal.

CAUTION

Focusing light on the detector surface increases the sensitivity of the measurement to variations in the detector response, and can lead to detector saturation and possible detector damage.

Although care is taken to select detectors with good unformity of the detector response over the surface, the calibration data supplied with detectors is for full surface illumination.

2.8.6 Detector Saturation

For small optical powers, the current generated by the photodiode is proportional to the optical signal incident upon the detector. For larger optical powers, saturation begins to occur, and the photodetector current is lower than would be expected if the output remained proportional to the signal. A typical saturation curve for a silicon photodiode is shown in Figure 2-5.

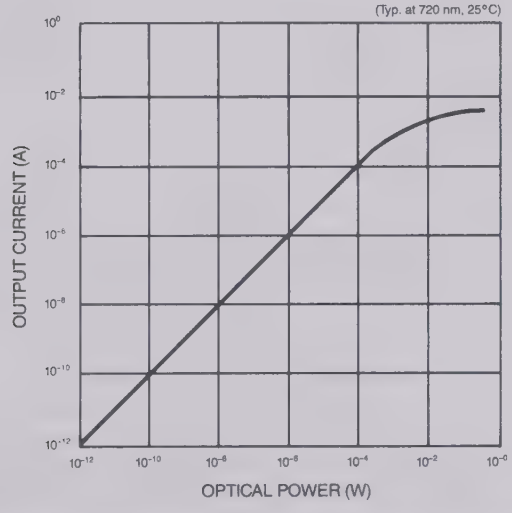


Fig. 2-5 Typical Silicon Photodetector Saturation Characteristics

Note that the saturation is "soft", i.e. the detector output does NOT suddenly stop increasing, but the rate of increase slows. For Gaussian and other signals with spatially varying intensities, local saturation may occur. The onset of saturation is not always obvious, and can lead to inaccurate measurements. Approximate saturation levels are given in the detector manuals. To see if a detector is saturating, reduce the optical power by a known amount, for example, by a factor of 1000 and verify that the reading is as expected. Calibrated attenuators supplied by Newport can be used for this purpose. If the reading is not as expected, apply an attenuator of known attenuation to reduce the optical power. The Model 835 Power Meter can be used to measure the transmission of the attenuator. Reduce the signal to a level small enough to avoid detector saturation, then place the attenuator in the beam path, and take another reading. The ratio of the two readings is the transmission of the attenuator.

2.8.7 Attenuator Characteristics

Optical attenuator characteristics also affect measurement accuracy. Most optical attenuators are sensitive to the angle of illumination, i.e. the angle at which light is incident upon them. For absorbing filters, the attenuation increases if the angle of incidence is not normal. Attenuators also have a transmission which depends upon wavelength. This wavelength dependence is measured and included in the calibration table stored in the Model 835 and is used to calculate the detector response when **ATTENUATOR** is lit on the LCD display.

2.8.8 Reflections and Interference Effects

The photodetector surface and window material reflect light. The amount of light reflected depends upon the angle of incidence and the polarization of the light. Reflected light does *NOT* get absorbed by the detector, and hence, is not included in the detector signal. The detector calibration includes the loss due to reflection for incoherent light normally incident upon the detector as sold by Newport Corporation. Use of the detector at non-normal angles of incidence will affect the reading.

2.8.9 Grounding Considerations

Input LO (outer ring of the connector) should not be connected to a potential at the source that exceeds 30V RMS from ground. The Model 835 will function properly if the detector is completely floating, i.e. not connected to any ground. However, with some detectors, the noise immunity will improve if the detector housing is connected to earth ground.

NOTE

The extremely high sensitivity Model 835 electronics are capable of detecting changes in the capacitance of the cable to ground or cable movement. When very low power measurements are being made, care should be taken to avoid moving the cable and to ground the outer shield of the cable if possible.

2.8.10 Changing Detectors

The Model 835 uses a programmable read only memory (PROM) to store the calibration data for each detector. Newport individually calibrates each detector, and programs the PROM with the individual calibration data. Different detector models have very different spectral response characteristics. To ensure the most accurate measurements, the PROM should also be changed according to the instructions in Section 5 whenever a new or recalibrated detector is used.

SECTION 3

PERFORMANCE VERIFICATION

3.1 INTRODUCTION

This section contains information to verify that the Model 835 electrical performance is within the specified accuracy. Model 835 specifications may be found at the front of this manual. Unfortunately, optical power standards are not generally available. To verify detector calibration, contact Newport Corporation. Ideally, performance verification should be performed when the instrument is first received to verify that no damage or change in calibration has occurred during shipment. The verification procedure may also be performed whenever instrument accuracy is suspect or following calibration. If performance on any of these ranges is outside specified limits, contact Newport Corporation

NOTE

If the instrument does not meet specifications and it is still under warranty (less than 12 months since date of shipment), contact your local Newport Corporation representative or the factory to determine the action to be taken.

3.2 ENVIRONMENTAL CONDITIONS

All measurements should be made with ambient temperature surrounding the display box between 18°C and 28°C (65° to 82° F) with a relative humidity less than 70%.

3.3 RECOMMENDED TEST EQUIPMENT

Equipment for verifying the performance of the Model 835 is listed in Table 3-1. Alternative equipment may be used as long as the equipment accuracy is at least as good as the specifications listed in Table 3-1. Interconnection of the test equipment is shown in Figure 3-1

Table 3-1 Recommended Current Calibration Equipment

Description	Specification	Mfr.	Model
Current Source	1.900 nA to 1.900 mA Required Accuracy: < 2 nA ± 0.4% < 20 nA ± 0.2% > 20 nA ± 0.1%	Keithley	220

Recommended Cables and Connectors:

(A) 3 ft. (1 m) TwinAx Connector	Trompeter	PL75-29
(B) TwinAx Cable	Trompeter	TWC 124-1A
(C) BNC Connector for TwinAx	Newport	13713-01

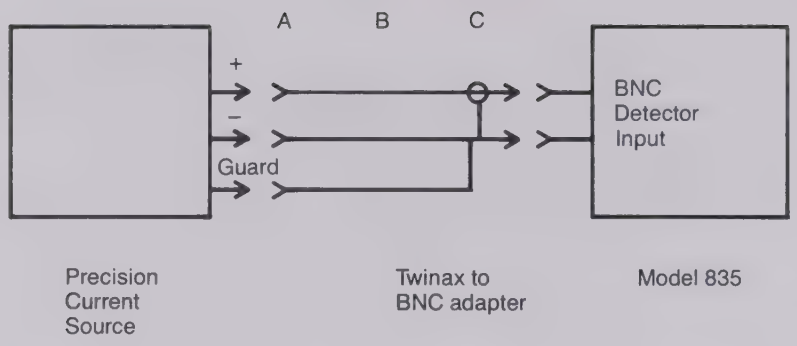


Fig. 3-1 Interconnection of Current Source and Model 835

3.4 INITIAL CONDITIONS

Before performing the verification procedures, make sure the Model 835 meets the following conditions:

1. If the instrument has been subject to temperatures below 18°C (65°F) or above 28°C (82°F), allow sufficient time for the instrument to reach temperatures within the range. Generally, it takes one hour to stabilize an instrument that is 10°C (18°F) outside of this range.
2. Turn on the Model 835 and allow it to warm up one hour. The instrument may be operated from either line power or battery pack power, as long as the battery pack has been fully charged as described in paragraph 2.2.3.

3.5 VERIFICATION PROCEDURE

The following paragraphs give the basic verfication procedure for checking accuracy.

To properly check the accuracy of the Model 835, a precision current source is necessary. The precise currents required are obtained by using a precisely settable current source such as the Keithley Instruments Model 220 connected to the Model 835 as shown in Figure 3-1.

Proceed as follows to check the accuracy of the Model 835:

NOTE

Record the following measurements and calculations in Table 3-2. Use pencil so that the table can be re-used.

Table 3-2 Calibration Check Table

835 Range	Desired Reading	Required Current	Actual Reading	Allowable Readings (18°C - 28 °C)
2 nW	1.9000 nW	_____	_____	1.8808 to 1.9192
20 nW	19.000 nW	_____	_____	18.857 to 19.143
200 nW	190.00 nW	_____	_____	188.95 to 191.05
2 µW	1.9000 µW	_____	_____	1.8932 to 1.9068
20 µW	19.000 µW	_____	_____	18.962 to 19.038
200 µW	190.00 µW	_____	_____	189.62 to 190.38
2 mW	1.9000 mW	_____	_____	1.8962 to 1.9038

Detector Response _____ A/W at _____ nm

The required current is obtained by multiplying the desired reading by the detector response at the wavelength set. For example, if the Model 835 is set for 850 nm, and the detector response at 850 nm is 0.55 A/W, the current setting on the 2 nW range is:

1.9000 nW x 0.55 A/W = 1.0450 nA

1. Set the Model 835 to a wavelength for which the detector response for which the PROM is programmed is accurately known. This information is given in the detector data sheets supplied with the detector. If the response is known for more than one wavelength, choose the wavelength for which the response is a maximum. Write the detector response in the space provided on the Table 3-2.
2. Calculate and record the current source settings required for each range as follows:

   Current Source Setting I = Reading X Response
3. Disconnect any inputs to the Model 835.
4. Depress ZERO CHECK and select the 2nA (most sensitive) range by pressing and holding RANGE until the most sensitive range is set.
5. With an open input, adjust the ZERO pot for .0000 ±1 count on the display.
6. With the current source power off, connect a Keithley Instruments Model 220 or equivalent precision current source to the input of the Model 835.
7. Set the Model 835 to the least sensitive range by pressing and holding RANGE ▲.
8. Using Table 3-2 as a guide, set the appropriate output current to the calculated setting and check the least sensitive range.
9. Repeat for all other ranges by changing the current source current and pressing RANGE ▼ momentarily once for each range.
10. Change the polarity of the current source, and repeat steps 7 through 9.

SECTION 4

THEORY OF OPERATION

4.1 INTRODUCTION

This section contains a brief overall functional description of the Model 835. Information pertaining to the Model 835-BAT Battery Pack option is also included. Component layout drawings (useful for changing the PROM) are located at the end of this instruction manual.

4.2 OVERALL FUNCTION DESCRIPTION

The Model 835 Power Meter system includes a photodetector and an electronic display. Each part is described in turn.

4.3 PHOTODETECTOR

The photodetector is a sensor which is connected to the electronic display through a cable with standard BNC connector. The photodetector is a semiconductor photodiode which generates current proportional to the total amount of light incident upon the detector. The photodetector is operated without bias to reduce dark currents and shot noise. The current is then measured by the electronic display, and converted into optical power as described in section 4.4.

Photodetector response characteristics depend upon many factors which are described in section 2.8 and in the appropriate photodetector calibration manual.

4.4 ELECTRONIC DISPLAY FUNCTIONAL DESCRIPTION

Basically, the Model 835 is a 4-1/2 digit, $\pm$20,000 count autoranging picoammeter with seven DC current ranges and a photodetector. A simplified block diagram of the Model 835 is shown in Figure 4-1. The heart of the Model 835 is a current to voltage converter followed by an A/D converter that translates the conditioned analog input signals into a form useable by the microcomputer.

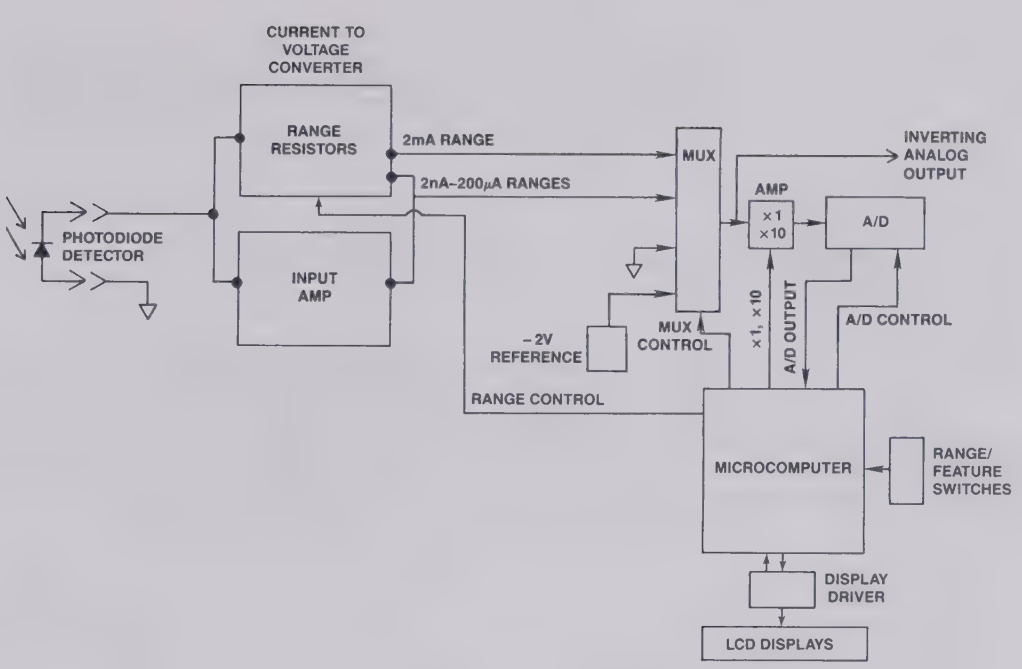


Fig. 4-1 Simplified Functional Block Diagram

4.4.1 Input Amplifier

The input buffer amplifier provides the necessary isolation between the input signal and the A/D converter. The amplifier is a non-inverting, low noise, high impedance circuit with x1 gain for the 20nA-2mA ranges and x10 gain for the 2nA range. The amplifier gain is controlled by the microprocessor. See Figure 2-3 for a functional diagram of the feedback picoammeter input amplifier circuit.

4.4.2 Microcomputer and PROM

The microcomputer performs the necessary calculations to convert from current to optical power using the detector response data stored in the programmable read-only memory (PROM). In addition, the microcomputer performs the mathematical operations neccessary to implement the features of the Model 835 such as Null, Reference (ratio), and Log (dBm, dB), and to drive the analog bar display.

The microcomputer centers around the 146805E2 CMOS microprocessor. It is an 8 bit processor. Software for the MPU is stored in U113 (PROM). Temporary storage is provided by a RAM which is used to store calibration constants on power-up and as RAM for the microprocessors in-house functions. A third memory, the non-volatile RAM (NVRAM) is used to store the current calibration constants and the power-up wavelength and attenuator status.

4.4.3 Power Supply

The LINE FUSE is internally accessible. S101 is the Power ON/OFF switch, and S102 selects 115V or 230V operations by placing the transformer primary windings in parallel or series.

The power transformer has two secondary windings, one for the Model 835 and the other for the IEEE option (Model 835-IEEE). A bridge rectifier functions as a fullwave rectifier for both the plus and minus supplies.

4.4.4 Model 835-BAT Rechargeable Battery Option

Maximum battery charging rate is achieved when the instrument is connected to line power and the ON/OFF switch is off. Fullwave rectified voltage is applied to charge the batteries. A transistor acts as a current sink if the charging current rises above 150 mA. The batteries are of the quick recharge type and will charge in 8 to 10 hours. With the instrument turned on the batteries will trickle charge at approximately 40 mA.

SECTION 5

MAINTENANCE

5.1 INTRODUCTION

This section contains the installation, photodetector calibration and service information for the Model 835 and 835-BAT Battery Pack.

WARNING

The procedures described in this section are for use only by qualified service personnel. Do not perform these procedures unless qualified to do so. Many of the steps covered in the section may expose the individual to potentially lethal voltages that could result in personal injury or death if normal safety precautions are not observed.

5.2 TOP COVER REMOVAL/ INSTALLATION

The top cover of the Model 835 must be removed in order to move the calibration jumper, service the unit, change the line frequency, change the PROM, or to install the Model 835-BAT battery pack and/or the Model 835-IEEE computer interface. Proceed as follows:

WARNING

Service by qualified personnel only. Disconnect the line cord and all other sources and cables before removing the top cover.

1. Turn off the power, disconnect the line cord and remove all test leads from the terminals of the Model 835.
2. Remove the 4-40 hex-head screws (4 each) from the top of the case.
3. Lift off the top cover, and separate from the unit.
4. To reinstall the top cover, reverse the above procedure.

5.3 BATTERY PACK (MODEL 835-BAT) INSTALLATION

Refer to Figure 6-1 and perform the following procedure to install the battery pack:

WARNING

Service by qualified personnel only. Disconnect line cord and remove all test leads from terminals of the Model 835.

1. Remove the top cover as explained in paragraph 5.2.
2. Remove the four screws securing the shield to the mother board.
3. Position the battery board on the metal shield and secure it to the shield using two supplied screws. The screws are fed through the shield into the battery board fasteners.

4. Place the battery pack in the bracket and position it on the shield as shown. Feed the two screws through the shield into the bracket and tighten.

CAUTION

Do not allow the battery leads to short together or damage to the batteries may occur.

5. Carefully place the shield (with battery pack) back into the Model 835 and replace the four screws securing it.
6. Connect the ribbon cable from the battery board to the male connector (marked BAT) on the mother board. Take care to ensure that the plug is centered on the pins, and that it is not shifted to one side.

CAUTION

Make a close visual inspection to ensure that the connector is properly mated or damage to the instrument may result.

7. Connect the red battery lead to the +RED terminal pin on the battery board. Connect the black battery lead to the -BLK terminal pin on the battery board.
8. Reinstall the top cover as explained in paragraph 5.2
9. Charge the battery pack per instructions in paragraph 2.2.1.

5.4 SPECIAL HANDLING OF STATIC SENSITIVE DEVICES

Some of the electronic circuits used in the Model 835 contain are CMOS devices designed to operate at very high impedance levels for low power consumption. As a result, any normal static discharge that builds up on your body or clothing may be sufficient to destroy these devices if they are not handled properly. In particular, the programmable read-only memory (PROM) used to store the detector response characteristics should be handled using the following precautions to avoid damaging them:

1. The PROM should be transported and handled only in containers specially designed to prevent static build-up. Typically, PROMs will be received in static-protective containers until ready for installation.
2. Remove PROMs from their protective containers only at a properly grounded work station. Also ground yourself with a suitable wrist-strap.
3. Handle the PROM only by the body; do not touch the pins.
4. PC boards must be grounded to the bench while inserting PROMs.

5.5 DETECTOR AND ATTENUATOR RECALIBRATION OR REPLACEMENT

Calibration data for individual detectors are stored in a programmable read-only memory (PROM) on the mother board of the Model 835. The Model 835 may be used with detectors or attenuators other than the detector/attenuator supplied with the unit. However, the PROM which

contains the calibration data should be replaced with one calibrated for the detector/attenuator combination being used.

When a detector/attenuator is recalibrated, a new PROM with the new calibration data will be sent with the detector if the PROM is properly ordered with the recalibration.

Paragraph 5.5.1 gives the procedure for removing the PROM and replacing it with another.

5.5.1 PROM Replacement Procedure

CAUTION

It is important to follow the handling procedures in paragraph 5.4 to avoid damaging the PROM.

To replace a PROM in the Model 835, follow the procedure below:

1. Remove the top cover as described in paragraph 5.2
2. Using a PROM puller, remove chip U113 from its socket. See figure 6-2 for the position of U113. It is located on the main circuit board on the right hand side as viewed from the front of the instrument. It can be identified by the label applied to the top of the top of the chip.
3. Place the removed PROM in a piece of conductive foam to avoid damage from possible static discharges. Keep this PROM for later use if the detector is replaced and may be used again in the future.
4. Remove the new PROM from its protective packaging, and insert into the socket for U113, taking care to orient the small indentation in the PROM the same way as shown in Figure 6-3.
5. Make a careful visual inspection of the PROM and check to be sure that all pins are in the proper positions in the socket, and that none have been bent.
6. Replace the top cover as described in paragraph 5.2

The Model 835 should now be ready for functional use with the new PROM. Plug in the instrument, and press λ CAL ▲ until the serial number is displayed as described in paragraph 2.7.3, Note 3. Verify that both the detector and attenuator serial numbers match the serial numbers for the detector and attenuator used. The Model 835 is now ready for general use.

5.6 IEEE-488 (Model 835-IEEE) Interface Installation

Installation of the Model 835-IEEE computer interface is described in detail in the instruction manual for the Model 835-IEEE.

5.7 TROUBLESHOOTING AND SELF-DIAGNOSTIC PROGRAM

A self-diagnostic program is contained in the Model 835 firmware. The self-diagnostic program can be used to learn the software revision and to aid in the isolation of defective components of the Model 835.

To enter the self-diagnostic program, power-up the Model 835 while holding in the AUTO button. The following will occur:

1. All LCD digits and annunciators will turn on.
2. The software revision level will be displayed (i.e. A1).
3. The Model 835 will go into troubleshooting test mode.

To exit self-diagnostic mode, turn the power off then on.

SECTION 6

SERVICE

6.1 INTRODUCTION

This section contains information about servicing the Model 835 and accessories, and component location drawings. The Model 835 is designed to be serviced by replacing PC boards. This method eliminates the need for the user to return the entire unit to the factory for repair. In some instances, however, field repair may be more appropriate. Contact Newport Corporation or your Newport representative for assistance.

6.2 FACTORY SERVICE

To obtain information concerning factory service, contact the factory or your Newport representative. Please have the following information available:

1. Instrument Model Number
2. Instrument Serial Number
3. Detector Serial Number and, if available, calibration date.
4. Attenuator Serial Number and, if available, calibration date.
5. Description of problem

When returning the instrument to Newport, please complete the service form which follows this section and return it with the instrument or circuit boards.

6.3 COMPONENT LOCATION DRAWINGS

Figure 6-1. Exploded View of Model 835

Figure 6-2. Mother Board, Component Layout

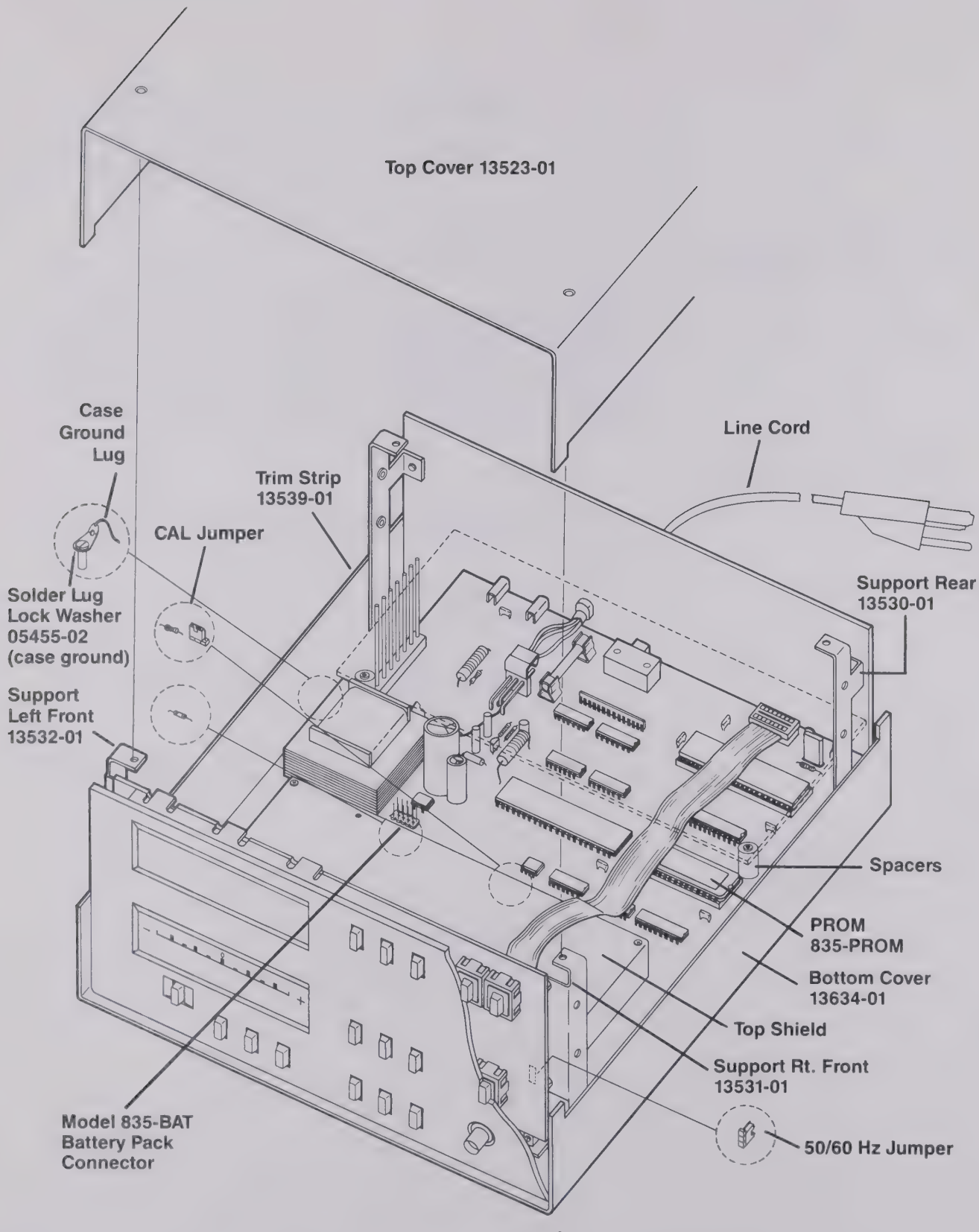


Fig. 6-1 Exploded View of Model 835

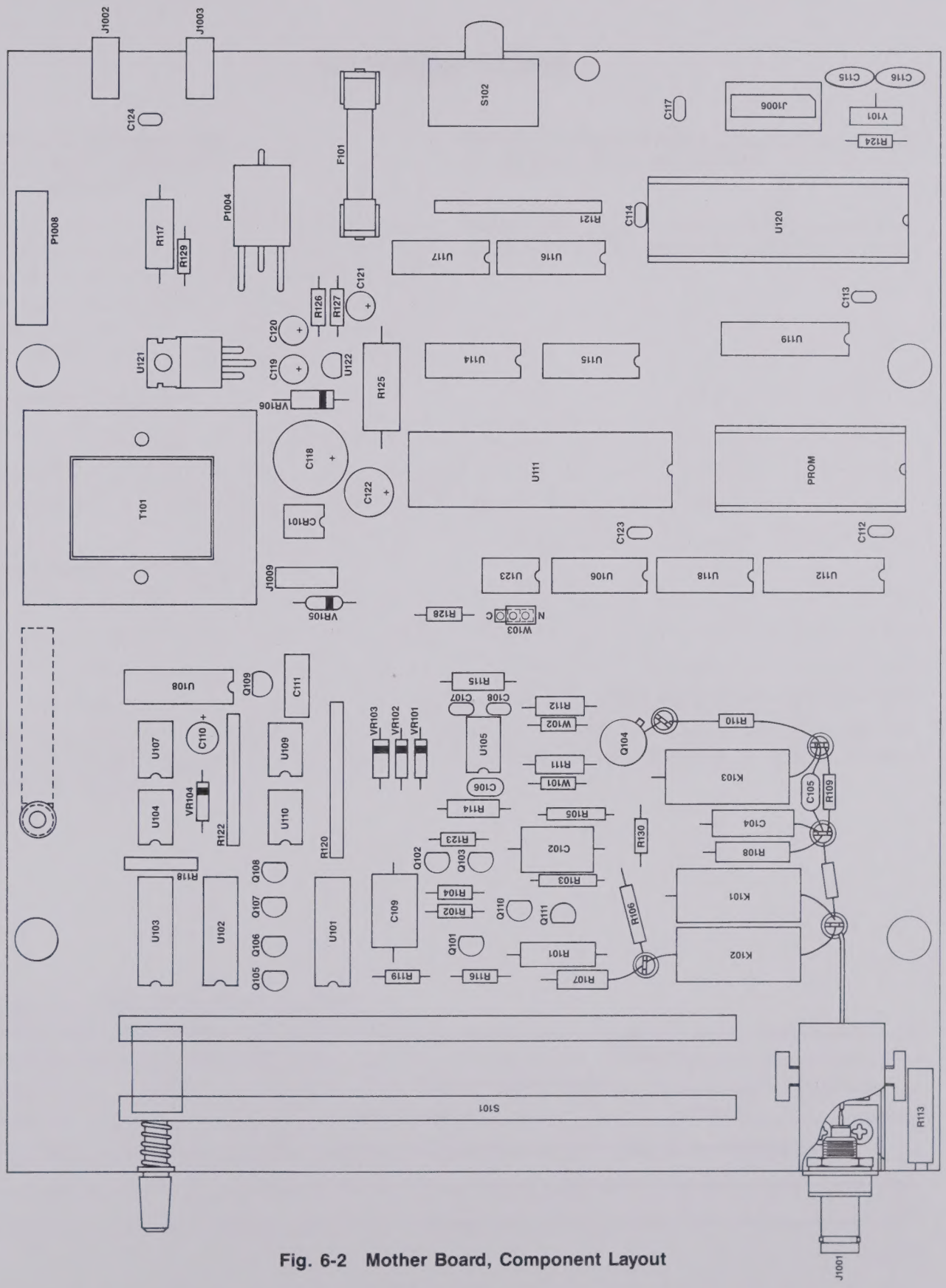


Fig. 6-2 Mother Board, Component Layout

SERVICE FORM

NEWPORT CORPORATION
U.S.A. Office: 714/963-9811
FAX: 714/963-2015

RETURN AUTHORIZATION # _____
(Please obtain prior to return of item)

Name _____ Date _____
Company _____ Phone Number _____
Address _____
_____
Country _____
P.O. Number _____

Item(s) Being Returned:

Model # _____ Serial # _____

Description _____

Reason for return of goods (please list any specific problems) _____

_____

Please complete below, as appropriate.
List all control settings and describe problem _____

_____

_____

_____ (Attach additional sheets as necessary).

Show a block diagram of your measurement system including all instruments connected (whether power is turned on or not). Describe signal source. If source is a laser, describe output mode, peak power, pulse width, repetition rate and energy density.

Where is the measurement being performed?
(factory, controlled laboratory, out-of-doors, etc.) _____

What power line voltage is used? _____ Variation? _____

Frequency? _____ Ambient Temperature? _____

Variation? _____ °F. Rel. Humidity? _____ Other? _____

Any additional information. (If special modifications have been made by the user, please describe below).

_____

_____

MP MASTER
MA29626

P/N 13767-01
IN-01872 (Rev. 4-24-89)

Newport Corporation
U.S. Office:
18235 Mt. Baldy Circle
P.O. Box 8020
Fountain Valley, CA 92728
Telephone: (714) 963-9811
Facsimile: (714) 963-2015

European Offices:
Newport GmbH
Bleichstrasse 26
D-6100, Darmstadt
West Germany
Telephone: 06151-26116
Facsimile: 06151-22639

Newport Ltd.
Pembroke House
Thompsons Close
Harpenden, Herts. AL5 4ES
Telephone: 05827-69995
Facsimile: 05827-62655

Newport